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(54) **DOWNHOLE TOOLS AND METHODS OF CONTROLLING DOWNHOLE TOOLS**

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E21B 23/00	(2006.01)
E21B 23/01	(2006.01)
E21B 23/04	(2006.01)
E21B 17/10	(2006.01)

(52) **U.S. Cl.**
CPC ***E21B 23/00*** (2013.01); ***E21B 17/1021*** (2013.01); ***E21B 23/01*** (2013.01); ***E21B 23/04*** (2013.01); *E21B 2023/008* (2013.01)

(58) **Field of Classification Search**
CPC E21B 4/18; E21B 2023/008; E21B 23/01; E21B 23/04; E21B 17/1021
See application file for complete search history.

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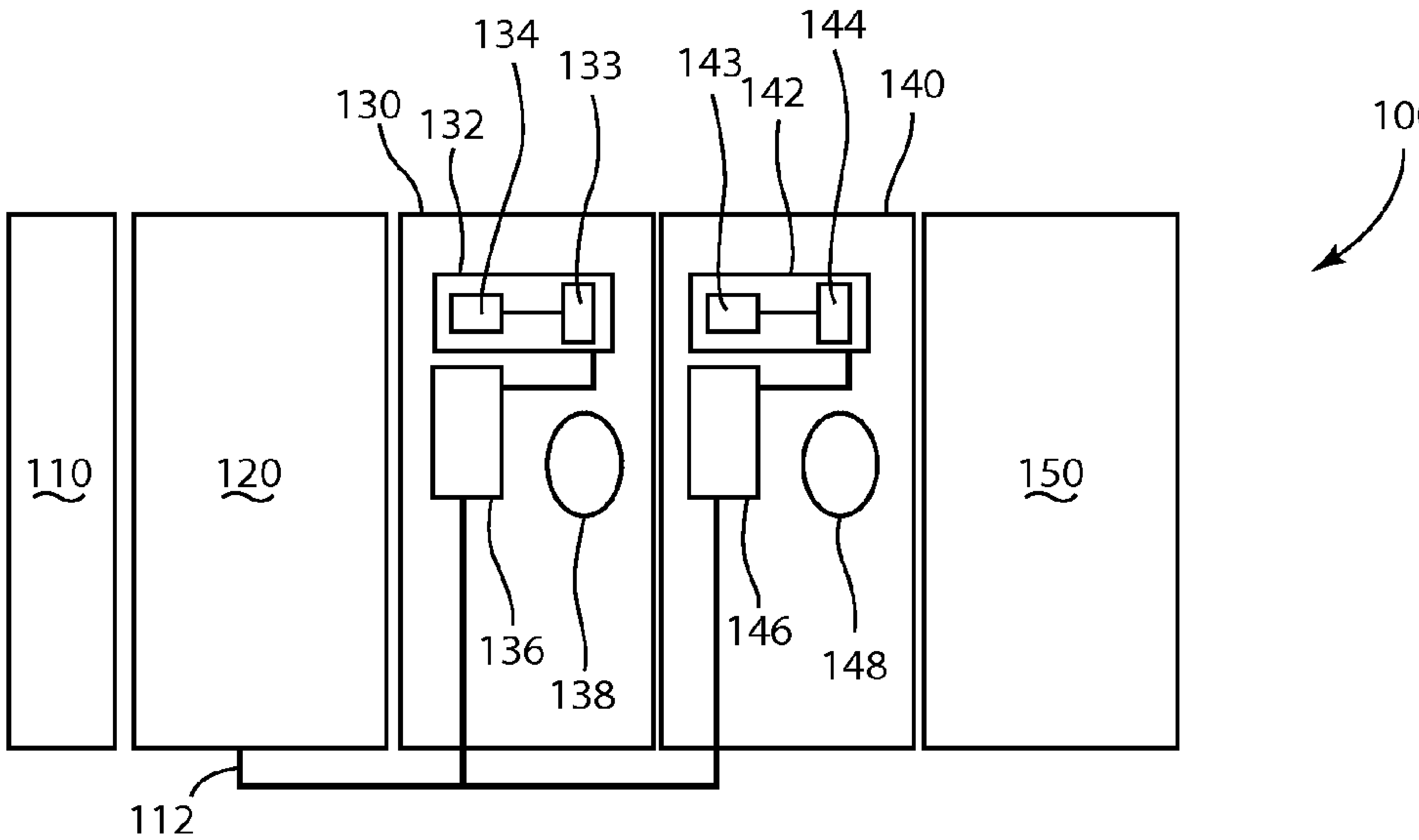
(57) **ABSTRACT**

A downhole tool that has a plurality of arm assemblies. Each of the arm assemblies has an arm configured to expand and retract and an actuator. A hydraulic bus in fluid communication with the plurality of arm assemblies. A plurality of flow control devices. The flow control devices are configured to selectively isolate one or more arm assemblies of the plurality of arm assemblies from the hydraulic bus while maintaining the other arm assemblies of the plurality of arm assemblies in communication with the hydraulic bus.

9 Claims, 5 Drawing Sheets



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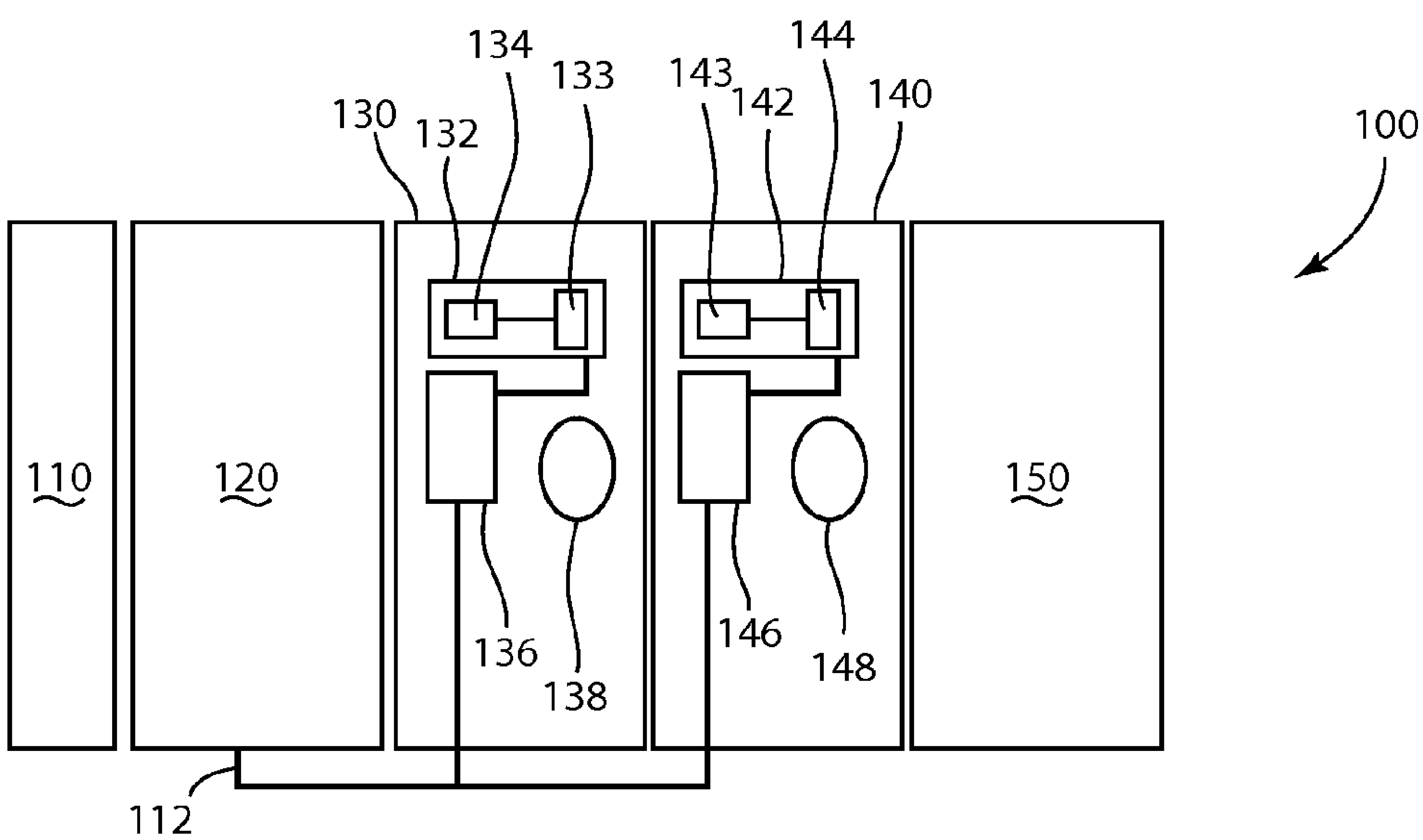
100
110
120
130
132
134
133
136
138
140
142
143
144
146
148
150
112

FIG. 1

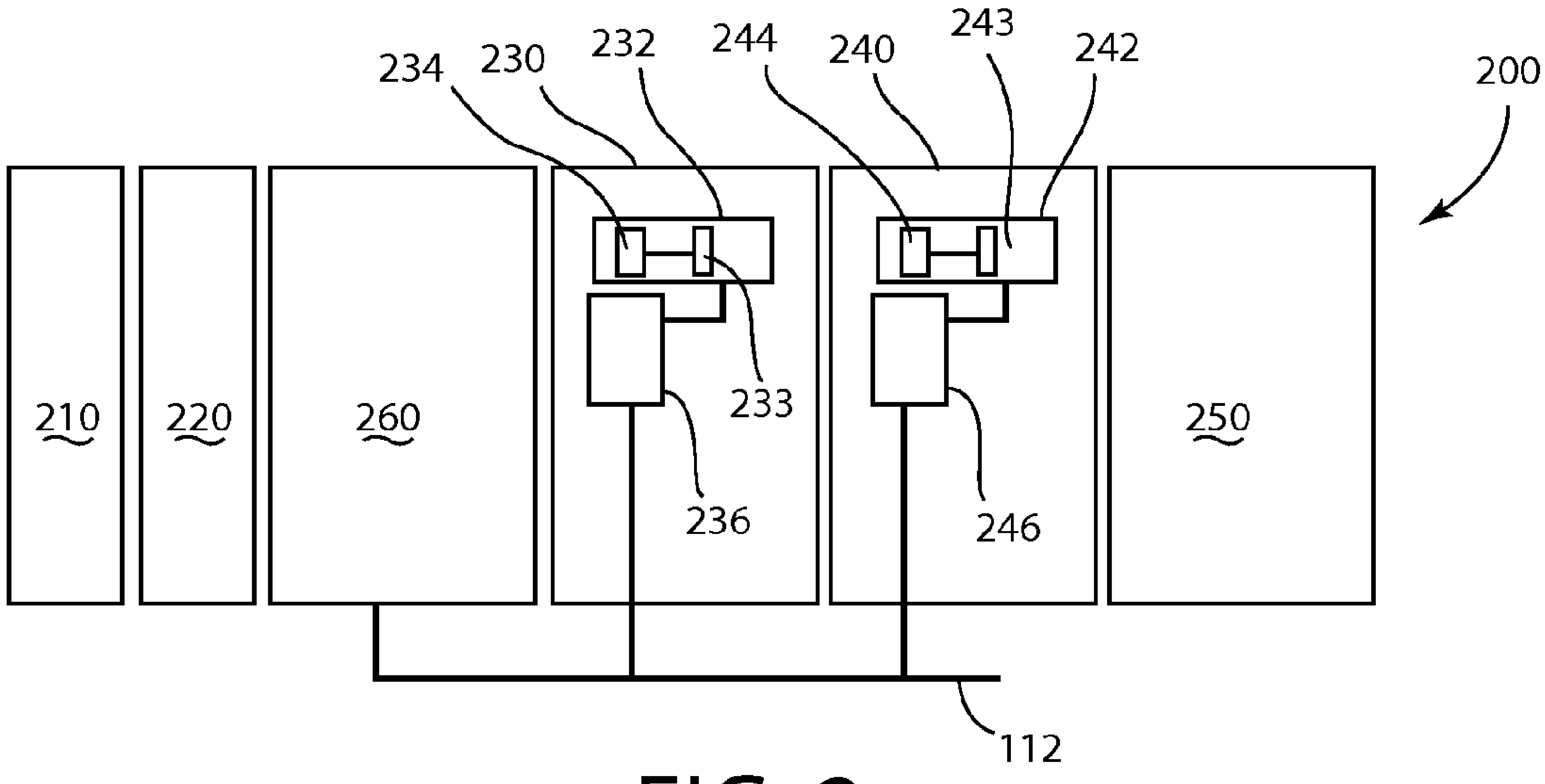
200
210
220
260
230
232
233
234
236
240
242
243
244
246
250
112

FIG. 2

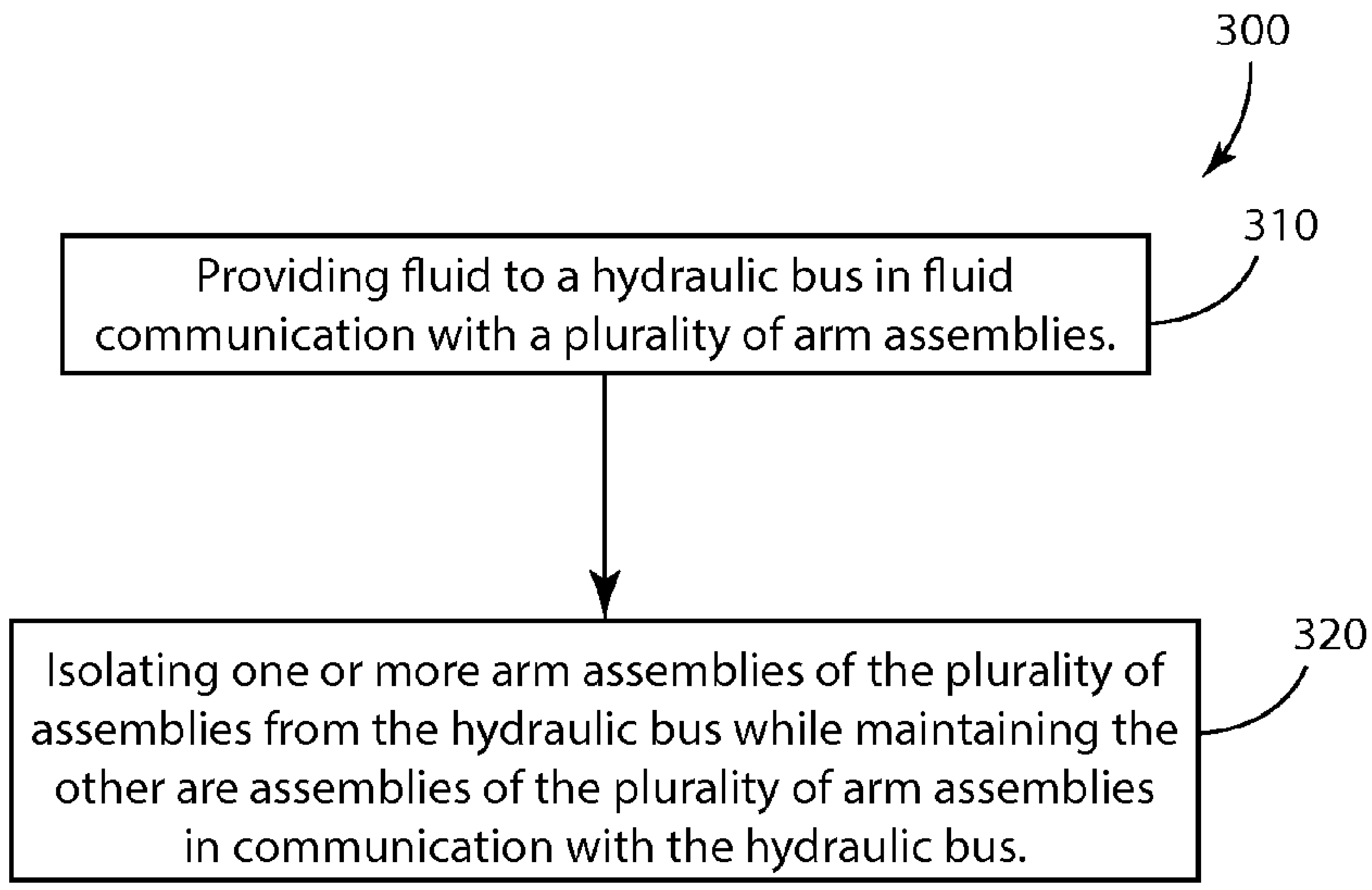
300
310
Providing fluid to a hydraulic bus in fluid communication with a plurality of arm assemblies.
320
Isolating one or more arm assemblies of the plurality of assemblies from the hydraulic bus while maintaining the other are assemblies of the plurality of arm assemblies in communication with the hydraulic bus.

FIG. 3

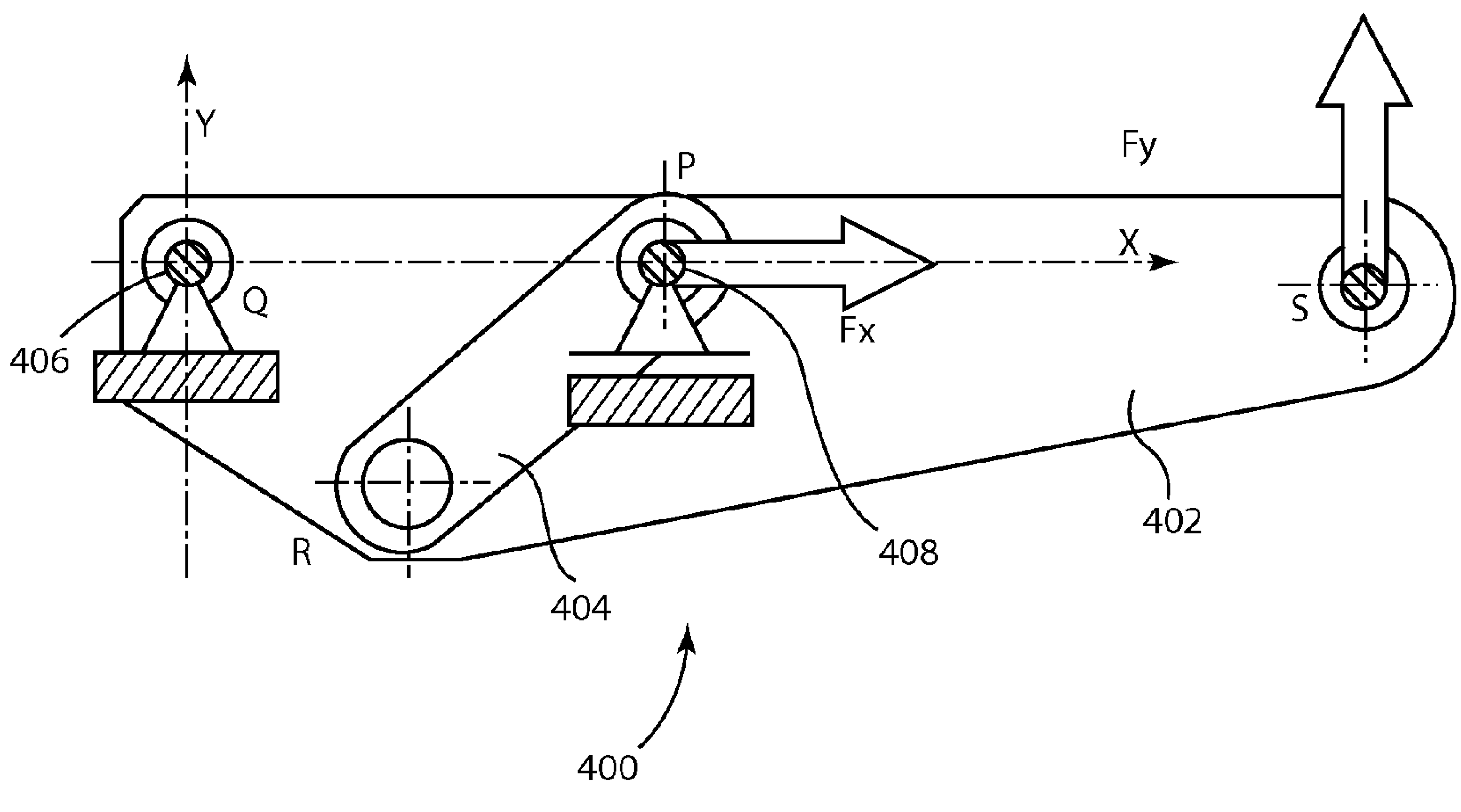
Y
P
Fy
X
Q
Fx
S
406
408
402
R
404
400

FIG. 4

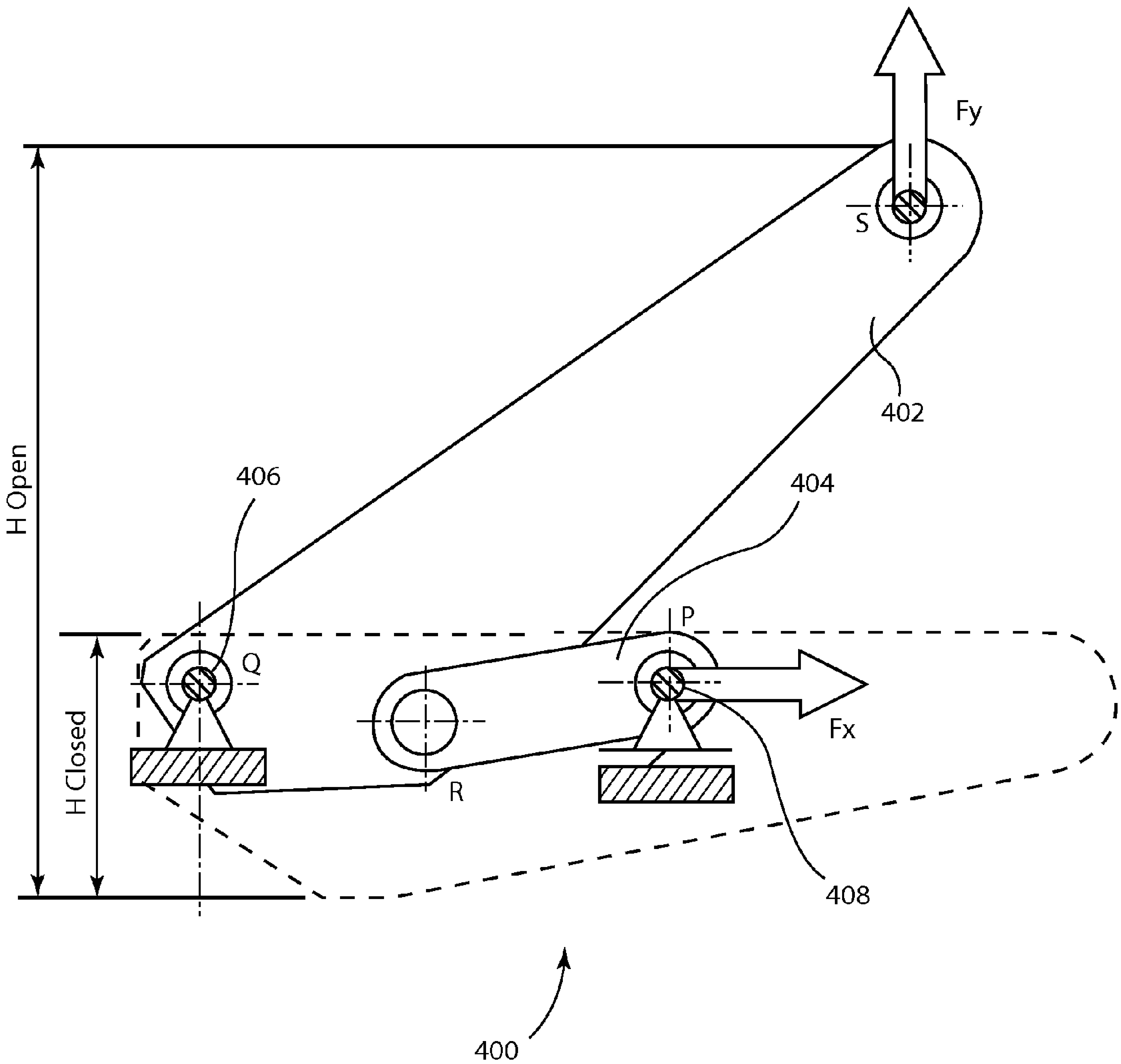

FIG. 5

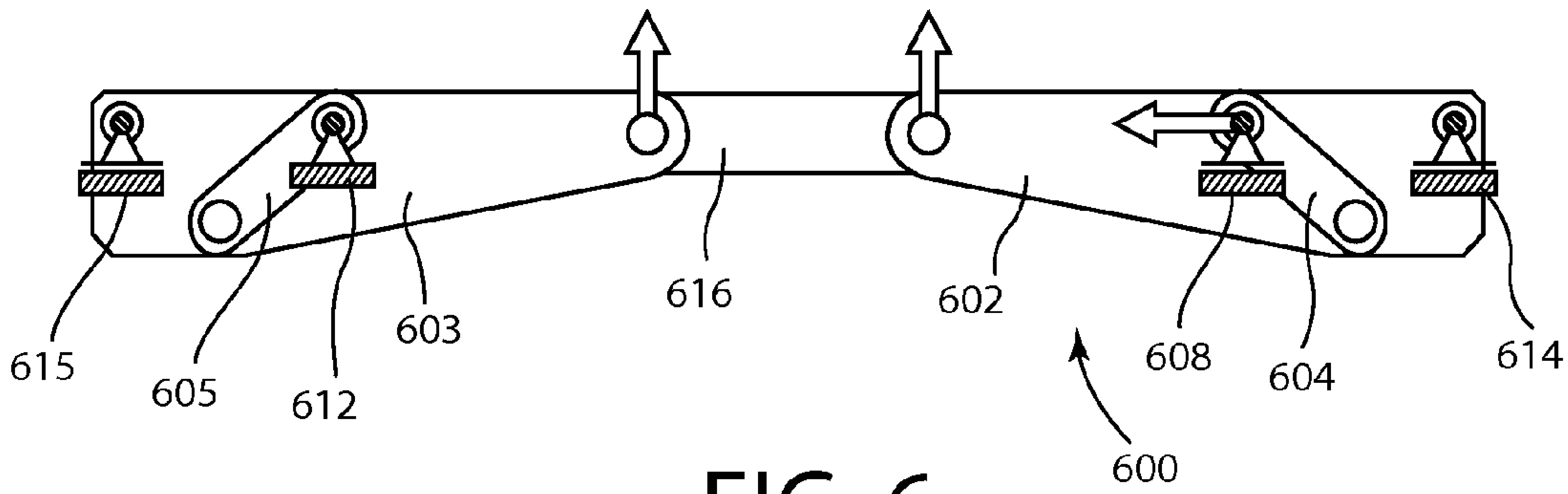

FIG. 6

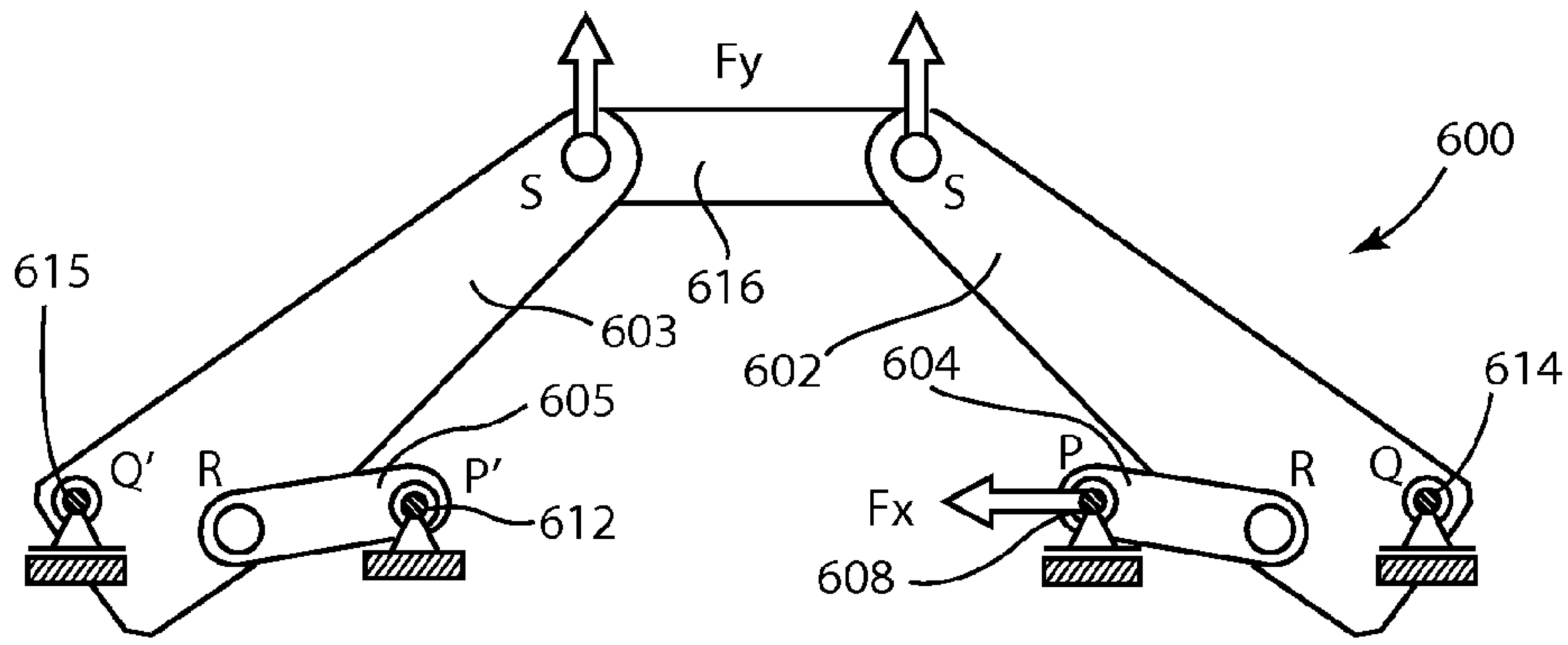

FIG. 7

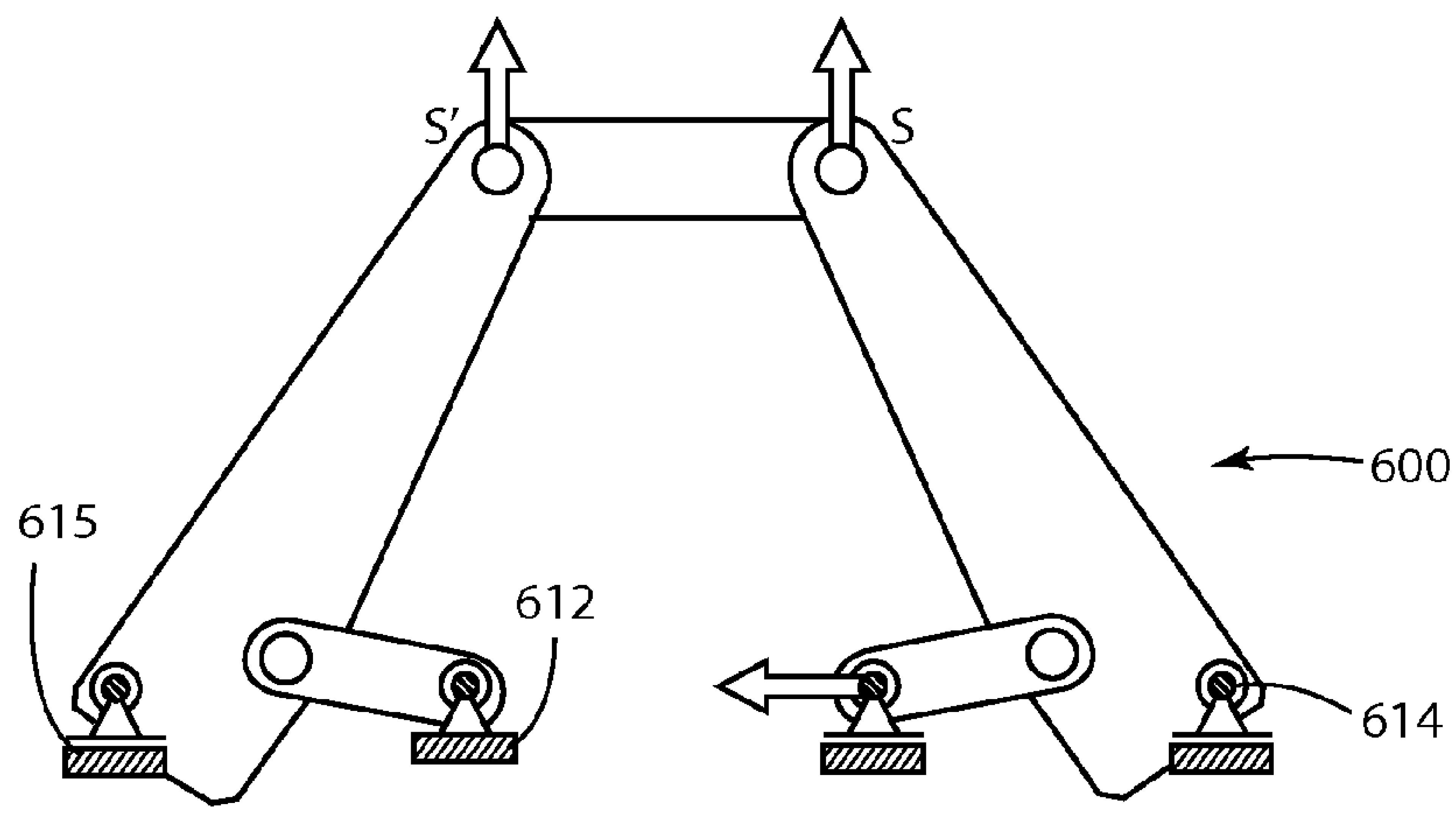

FIG. 8

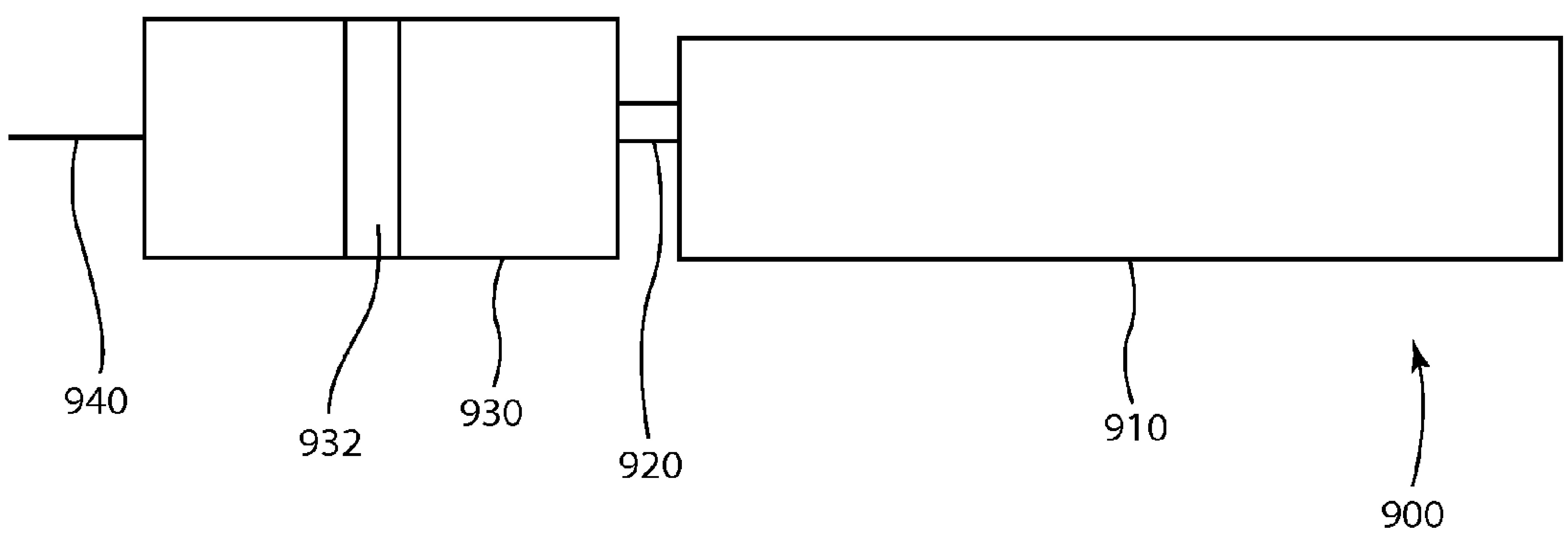

FIG. 9

DOWNHOLE TOOLS AND METHODS OF CONTROLLING DOWNHOLE TOOLS

FIELD OF THE DISCLOSURE

The disclosure generally relates to downhole tools and methods of controlling downhole tools.

BACKGROUND

Downhole tools, such as tractors, often need to negotiate obstacles in wellbores. However, individual control of arms of traditional tractors is not possible; thereby, hindering the ability of traditional tractors to negotiate restrictions in the wellbore or isolate a failed motor.

SUMMARY

An embodiment of a downhole tool may include a plurality of arm assemblies. Each of the arm assemblies can include an arm configured to expand and retract and an actuator. The downhole tool may also include a hydraulic bus. The hydraulic bus may be in fluid communication with the plurality of arm assemblies; and a plurality of flow control devices. The flow control devices can be configured to selectively isolate individual arm assemblies of the plurality of arm assemblies from the hydraulic bus.

Another embodiment of the downhole tool may include a plurality of arm assemblies, and each of the arm assemblies may include an arm configured to expand and retract and an actuator. The plurality of arm assemblies can be in fluid communication with a hydraulic bus. The downhole tool may also include a plurality of flow control devices; and the flow control devices can be configured to selectively isolate individual arm assemblies of the plurality of arm assemblies from the hydraulic bus. The downhole tool can also include a control module in communication with the plurality of flow control devices, and a sensor can be in communication with the control module.

An example method of controlling arm activation of a downhole tool can include providing fluid to a hydraulic bus in fluid communication with a plurality of arm assemblies; and isolating individual arm assemblies of the plurality of arm assemblies from the hydraulic bus.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a schematic of an embodiment of the downhole tool.

FIG. **2** depicts a schematic of another embodiment of a downhole tool.

FIG. **3** depicts a flow diagram of an example method of controlling arm activation of a downhole tool.

FIG. **4** depicts a schematic of an example constant force actuator in a closed position.

FIG. **5** depicts a schematic of the example constant force actuator of FIG. **4** in an open positon.

FIG. **6** depicts a schematic of another example constant force actuator in a closed positon.

FIG. **7** depicts a schematic of the constant force actuator in FIG. **6** in a partially radially expanded state.

FIG. **8** depicts a schematic of the constant force actuator of FIG. **6** in a fully radially expanded state.

FIG. **9** depicts a schematic of an assembly including an anchor connected with a downhole tool.

DETAILED DESCRIPTION OF THE INVENTION

Certain examples are shown in the above-identified figures and described in detail below. In describing these examples, like or identical reference numbers are used to identify common or similar elements. The figures are not necessarily to scale and certain features and certain views of the figures may be shown exaggerated in scale or in schematic for clarity and/or conciseness.

An embodiment of a downhole tool includes a plurality of arm assemblies. The arm assemblies include an arm configured to expand and retract and an actuator. The example downhole tool also includes a hydraulic bus in fluid communication with the plurality of arm assemblies; and a plurality of flow control devices. The flow control devices are configured to selectively isolate individual arm assemblies of the plurality of arm assemblies from the hydraulic bus.

An embodiment of a downhole tool can also include a control module in communication with the plurality of flow control devices and at least one sensor. The sensor can be a caliper located on the downhole tool below a drive section, and the control module can receive wellbore diameter data from the caliper and selectively isolate individual arm assemblies of the plurality of arm assemblies according to the wellbore diameter data. The control module can be a microprocessor configured to receive the wellbore data and control the plurality of flow control devices to selectively isolate individual arm assemblies, allowing selective closure of the arm assemblies according to the wellbore diameter data. The control module can also receive feedback from motors associated with the arm assemblies and control the plurality of flow control devices to isolate arm assemblies associated with a failed motor from the hydraulic bus.

FIG. **1** depicts a schematic of an embodiment of a downhole tool. The downhole tool **100** can contain a control module **110**, a hydraulic module **120**, a first drive module **130**, a second drive module **140**, and a sensor **150**.

The control module **110** can contain one or more microprocessors configured to control components of the tool. For example, one microprocessor can control a pump in the hydraulic module **120**, a second microprocessor can control flow control devices **136** and **146**, and a third microprocessor can control motors **138** and **148**. Of course, each motor can be controlled by two independent microprocessors. Two microprocessors can also control the flow control devices. Other now known or future known configurations and methods of controlling the components of the downhole tool **100** can also be used.

The hydraulic module **120** can include a hydraulic system including a pump, motor, valves, and flow lines. Any now known or future known hydraulic systems can be used.

The flow control devices **136** and **146** can be any adjustable flow control device. The flow control devices can be solenoid valves.

The sensor module **150** can be a caliper or other sensor configured to acquire downhole data. The downhole data can include wellbore diameter, temperature, pressure, downhole tool velocity, or combinations thereof.

The hydraulic module **120** can provide pressurized fluid to the drive modules **130** and **140** via hydraulic bus **112**.

The first drive module **130** can include the first flow control device **136**, the first motor **138**, and a first arm assembly **132**. The first arm assembly **132** can include an actuator **133** and a first arm **134**.

The second drive module **140** can include the second flow control device **146**, a second arm assembly **142**, and the second motor **148**. The second arm assembly **142** can include a second actuator **143** connected with a second arm **144**.

The actuators **133** and **143** can be any now known or future known activation device. An illustrative actuator is hydraulically operated, and as a piston is moved the connected arm is radially expanded. The arms **134** and **144** can be connected with the actuators **133** and **143** using any now known or future known techniques. The arms **134** and **144** can have a wheel, roller, or the like on an end thereof. The wheel, roller, or the like can be driven by the first motor **138** to provide movement to the downhole tool.

The first flow control device **136** can be selectively controlled to allow fluid communication of a first arm activation assembly **132** with the hydraulic bus **112**, and the second flow control device **146** can be selectively controlled to allow fluid communication between the second arm activation assembly **142** and the hydraulic bus **112**. For example, if the control module determines that the first motor **138** has stopped working, the control module **110** can close the first flow control device; thereby, preventing communication between the hydraulic bus **112** and the first arm activation device **133**. Accordingly, the first arm activation assembly **133** will not radially expand the first arm **134**, and the second arm **144** can remain radially expanded.

In another example, the sensor module **150** can determine that there is a reduction in the wellbore, the speed of the downhole tool can be determined using now known techniques or future known techniques, and distance of each drive module **130** and **142** can be known. The control module **150** can use these parameters to determine that there is an obstruction and if the arms of the drive module need to be retraced and when the first arm **134** and the second arm **144** need to be retracted. To allow retraction of the arms **134** and **144**, the control module **110** can selectively close the flow control devices **136** and **146** respectively.

FIG. **2** depicts a schematic of another embodiment of a downhole tool. The downhole tool **200** can include a control module **210**, a sensor module **250**, a first drive module **230**, a second drive module **240**, a hydraulic bus **112**, a hydraulic module **220**, and a motor module **260**.

The control module **210** can include one or more microprocessors and other equipment allowing the control module **210** to control the components of the down hole tool **200**.

The motor module **260** can be operatively connected with the drive modules **230** and **240**, allowing the motor module **260** to provide power to both drive modules **230** and **240**. The motor module **260** can be connected with the drive modules **230** and **240** using a drive shaft, gear box, continuous variable transmission, other now known or future known drive components, or combinations thereof.

The first drive module **230** can include a first flow control device **236** and a first arm assembly **232**. The first arm assembly **232** can include an actuator **233** and a first arm **234**.

The second drive module **240** can include a second flow control device **246** and second arm assembly **242**. The second arm assembly **242** can include a second actuator **243** connected with a second arm **244**.

The actuators **233** and **243** can be any now known or future known activation device. An illustrative actuator is hydraulically operated, and as a piston is moved the connected arm is radially expanded. The arms **234** and **244** can be connected with the actuators **233** and **243** using any now known or future known techniques. The arms **234** and **244** can have a wheel, roller, or the like on an end thereof. The wheel, roller, or the like can be driven by the motor module **260** to provide movement to the downhole tool.

The sensor module **250** can be a caliper or other sensor configured to acquire downhole data. The downhole data can include wellbore diameter, temperature, pressure, downhole tool velocity, or combinations thereof.

FIG. **3** depicts a flow diagram of an example method of controlling arm activation of a downhole tool. The method **300** can include providing fluid to a hydraulic bus in fluid communication with a plurality of arm assemblies (Block **310**). The method **300** can also include isolating one or more arm assemblies from the plurality of arm assemblies from the hydraulic bus while maintaining the other arm assemblies of the plurality of arm assemblies in communication with the hydraulic bus (Block **320**). Isolating can include closing one or more flow control devices. The one or more arm assemblies of the plurality of arm assemblies can be isolated from the hydraulic bus in response to data acquired by a sensor in communication with a control module.

In one or more embodiments each of the arm assemblies of the plurality of arm assemblies can include a constant force actuator. The constant force actuator disclosed herein can be used with other downhole tools as well. For example, the constant force actuator can be used to expand a centralizer, a caliper, an anchor, or other radially expanding components of a downhole tool.

FIG. **4** depicts a schematic of an example constant force actuator in a closed position. FIG. **5** depicts a schematic of the example constant force actuator of FIG. **4** in an open positon.

Referring now to FIG. **4** and FIG. **5**, the constant force actuator **400** includes a fixed support **406**, an arm **402**, a link **404**, and a slide **408**. The constant force actuator **400** has a closed height, represented as Hclosed, and an open height, represented as Hopen. The actuator **400** can be moved from the closed position by applying an axial force, represented as Fx, to the slider **408**. The slide **408** will move the link **404**, causing the arm **402** to pivot about a connection on the fixed support **406**. The pivoting will continue until the arm contacts a borehole wall or other obstruction, and then a radial force, represented as Fy, will be exerted on the borehole wall or other obstruction at a point S.

The constant force actuator **400** can have a force ratio of Radial Force=Fy/Fx. The constant force actuator **400** can have an expansion ratio as Expansion Ratio=Hopen/Hclosed. The constant force actuator can have a constant radial force for any position of the slider **408** within the range defined by Hopen and Hclosed.

FIG. **6** depicts a schematic of another example constant force actuator in a closed positon. FIG. **7** depicts a schematic of the constant force actuator in FIG. **6** in a partially radially expanded state. FIG. **8** depicts a schematic of the constant force actuator of FIG. **6** in a fully radially expanded state.

Referring now to FIG. **6**, FIG. **7**, and FIG. **8**, the constant force actuator **600** includes a first arm **602**, a second arm **603**, a first link **604**, a second link **605**, a fixed support **612**, a slider **608**, a first moveable support **614**, a second movable support **615**, and a bar **616**. In one or more embodiments, the bar **616** can be omitted.

The slider **608** can have an axial force, designated as Fx, applied thereto, and as the slider **608** moves in the direction of the axial force Fx, the distance between point P and point P' is decreased and the arms **602** and **603** can expand radially. The movable support **614** and **615** allow the pivots Q and Q' connected with the arms **602** and **603**, respectively, to translate axially. The arms **602** and **603** can radially expand until coming into contact with a borehole wall or other obstruction. Upon contacting the borehole wall or other obstruction, a radial force, designated as Fy, can be applied to the borehole wall or other obstruction. The radial force Fy will be applied at points S and S'. In one or more embodiments, the constant force actuator **600** can be used as a centralizer or anchor. In an embodiment where the constant force actuator **600** is used as an anchor, the radial force Fy can be used to secure a downhole tool within the borehole. The constant force actuator **600** can have an expansion ratio from about 3:1 to about 7:1, and the consistency of the force ratio can be preserved throughout the expansion.

FIG. **9** depicts a schematic of an assembly including an anchor connected with a downhole tool.

The system **900** can include a downhole tool **910**, a field joint **920**, an anchor module **930**, a constant force actuator **932**, and a conveyance **940**.

The downhole tool **910** can be any one described herein, a milling tool, a shifting tool, the like, or a combination thereof. The constant force actuator **932** can be any one of those described herein. The constant force actuator **932** can have axial force applied thereto by an electric linear actuator, a motor, a hydraulic actuator, other now know or future know force generating devices, or combinations thereof.

The conveyance **940** can be a wireline, slickline, coil tubing, or the like.

The system **900** can be conveyed into a borehole, and upon reaching a desired location in the borehole, the constant force actuator **932** can be activated to anchor the system **900** in the borehole to allow a downhole operation to be performed. The constant force actuator **932** can be retracted upon completion of the downhole operation, the system **900** can be moved to perform another downhole operation or retrieved to the surface.

Although example assemblies, methods, systems have been described herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers every method, apparatus, and article of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents.

What is claimed is:

1. A downhole tool comprising:

a plurality of drive modules in fluid communication with a hydraulic module and connected with the hydraulic module; wherein each drive module of the plurality of drive modules comprises: a radially expanding arm assembly, a wheel connected with the radially expanding arm, a motor connected with the wheel for driving the wheel, an actuation device for expanding the radially expanding arm, and a flow control device for controlling fluid communication between the actuation device the hydraulic module, wherein the plurality of drive modules are configured to provide movement to the downhole tool when the radially expanding arms are expanded and the wheels are in contact with a wellbore wall; and

a control module in communication with each of the drive modules of the plurality of drive modules and connected with the hydraulic module, and wherein the control module is configured to monitor each of the drive modules; wherein the control module is configured to instruct the first flow control device to prevent fluid communication with the first actuation device if the first motor is malfunctioning.

2. The downhole tool of claim **1**, wherein the plurality of the plurality of drive modules comprises a first drive module with a first motor, a first flow control device, and a first actuation device, and a second drive module with a second motor, a second flow control device, and a second actuation device.

3. The downhole tool of claim **1**, wherein each of the drive modules of the plurality of drive modules comprises a constant force actuator connected with the actuator.

4. A method of controlling arm activation of a downhole tool, wherein the method comprises:

moving a downhole tool in a wellbore by operating a first drive module by expanding a first arm assembly with a first wheel thereon and driving the first wheel with a first motor in the first drive module and operating a second drive module by expanding a second arm assembly with a second wheel thereon and driving the second wheel with a second motor in the second drive module; and

determining if there is an obstruction in a wellbore and speed of the downhole tool, and controlling a first flow control device in the first drive module and a second flow control device in the second drive module, to allow driving of the downhole tool and passage of the obstruction, wherein the controlling is performed by a control module configured to instruct the first flow control device to prevent fluid communication with the first actuation device if the first motor is malfunctioning.

5. A downhole tool comprising:

a hydraulic module;

a first drive module in fluid communication with the hydraulic module and connected with the hydraulic module, wherein the first drive module comprises a first flow control device operatively positioned to selectively control fluid communication between the hydraulic module and a first actuator, wherein the first actuator is configured to cause a first wheel to radially expand to engage a wellbore wall, wherein the first wheel radially expands into contact with the wellbore wall when the first actuator is in fluid communication with the hydraulic module, and wherein the first wheel is driven by a first motor;

a second drive module in fluid communication with the hydraulic module and connected with the first drive module, wherein the second drive module comprises a second flow control device operatively positioned to selectively control fluid communication between the hydraulic module and a second actuator, wherein the second actuator is configured to cause a second wheel to radially expand to engage a wellbore wall, wherein the second wheel radially expands into contact with the wellbore wall when the second actuator is in fluid communication with the hydraulic module, and wherein the second wheel is driven by a second motor; and

a control module in communication with the first drive module and the second drive module and connected with the hydraulic module, wherein the control module is configured to determine if the first motor or second motor are malfunctioning, and wherein if the first motor is determined to be malfunction, the control module closes the first flow control device, and if the second motor is malfunctioning, the control module closes the second flow control device.

6. The downhole tool of claim **5**, wherein the first actuator is a constant force actuator.

7. The downhole tool of claim **6**, wherein the constant force actuator comprise an arm, a fixed support, and a slider.

8. The downhole tool of claim **5**, wherein a constant force actuator is connected with the downhole tool, and wherein the constant force actuator comprises: a plurality of arms, a slider, a plurality of movable supports, and a fixed support.

9. The downhole tool of claim **8**, wherein the constant force actuator comprises a bar connecting a first arm of the plurality of arms with a second arm of the plurality of arms.

* * * * *